

In This Issue

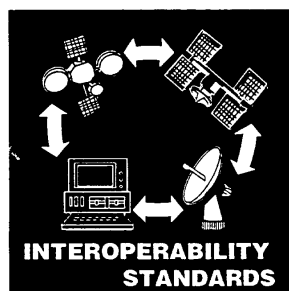
CHARLES STELZRIED AND MICHAEL KLEIN

In the lead article of this issue, M. L. MacMedan, manager of Information Systems Standards, describes this important program. Close interaction with the program is vital for the Telecommunications and Mission Operations Directorate (TMOD) Technology Program to successfully transfer new developments to DSN Implementation. The Information Systems Standards program is applicable to multiple missions, as well as to TMOD, and balances the design flexibility needed for performance improvements with the design stability that is characteristic of standardized systems. Implementation and operational costs for functions common to multiple missions are minimized. This successful effort also includes active work in the international forum of the Consultative Committee for Space Data Systems (CCSDS). The standardization approach for deep-space communications is key to the considerable cost savings available through greater use of Commercial-Off-the-Shelf (COTS) instrumentation.

In issues 6 and 7, Nasser Golshan described the highly successful LEO-T (Low Earth Orbit Terminal) 3-m antenna, an automated ground station for tracking the low-Earth orbiting satellites. This concept is now being extended to deep-space mission tracking with the DS-T (Deep Space Terminal) demonstration. Here, Golshan describes the new 34-m Beam Waveguide (BWG) antenna DSS-26, at Goldstone, that is being outfitted with LEO-T-derived instrumentation for this task. This demonstration provides another opportunity for lower-cost DSN services with autonomous, unattended operations, and direct data delivery to the investigator.

George Lutes gives an account of the progression of 'remoting' in the DSN. Introduction of the beam waveguide (BWG) antenna into the DSN permitted equipment that was formerly located on the antenna's structure to be moved to the ground. The next logical step is to move as much of this equipment as possible to the Signal Processing Center (SPC). This requires a Fiber Optics (FO)

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INFORMATION SYSTEMS STANDARDS OPEN NEW OPPORTUNITIES

M.L. MACMEDAN

Introduction

In the early days of the space program and for many years thereafter, JPL's missions were characterized by goals of perfection, optimization, and reliability. Cost was a factor, but often took a back seat. Today, we work under the guidance of "Faster, Better, Cheaper." No longer can we take the time or spend the money to customize routine operations for each mission. That is where standards come in.

Leading Standards

The objective of the Information Systems Standards Program is to develop "leading" standards to guide future designs in areas of common and routine operations, so that proportionally less money can be expended on the functions common to all missions, leaving more

money for the mission's nonroutine and unique needs.

"Leading" means the standards do not necessarily document what has been done before, but are well-engineered pathways to guide future end-to-end system designs to converge on a common way of doing the routine things that each spacecraft, tracking station, and ground processor do. Since no two missions are exactly the same, to apply a single standard over many missions requires it to have a certain flexibility to accommodate needed variations. On the other hand, this flexibility must necessarily be limited if we hope to control costs. Thus the standards represent a delicate balance between achieving functions that are "good enough" and at "reasonable cost" not for a single mission, but over the majority of them. As can be

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imagined, it is difficult to easily quantify such tradeoffs, especially with ill-defined future needs, and so good engineering judgment and vision are paramount to the success of a standard.

The importance of having well-engineered, leading standards to help make our missions more operable was emphasized by NASA when JPL was recently named the Lead Center for the NASA Space Mission Operations Standardization Program.

Technology

Leading standards must be based on the latest (or even not-yet-quite-available) technologies, because they will be used to guide designs of future missions. Technology having widespread applicability for future missions is always a candidate for a new or revised standard; it is not the intent of our standards program to unnecessarily lock in old techniques or stifle new ones. Therefore, there is a close relationship between the standards and the technology programs at both Goddard Space Flight Center (GSFC) and the Jet Propulsion Laboratory (JPL).

This relationship has been particularly successful in the area of packet telemetry where the standard has made feasible:

- the decoupling of the spacecraft data-collection process from the data-transmission process;
- self-identified, self-delimited data units to route and organize the processing and to support the variable length data structures inherent with data compression;
- self-identified "virtual" channels to replace (on a single data stream) the separate physical channels that were previously provided by using one or more rf subcarriers.

Other technology collaborations are channel coding, which is necessary to provide the nearly-error-free channel made necessary by compression, and the data-driven feature of packet telemetry; and data compression itself. Current collaborative work involves Turbo Codes, new techniques for Frame Synchronization, and development of a data set transfer protocol useful for assuring complete, error-free, end-to-end delivery in the long-time-delay environment of deep space.

Often, proposals for new missions are offered to the National Aeronautics and Space Administration (NASA) on the premise that the data system "will not be changed from the last project," thus saving lots of money. In actuality, this has never happened. In the end, some redesign has always

been necessary, because the point designs we have used in the past to optimize the data system for a particular mission have no flexibility to accommodate even the limited changes necessary to work with a different project. These standards do allow for a range of flexibility to accommodate not all, but a majority of new missions.

Widespread Cooperation

Rather than develop standards in isolation just for JPL, with its small market, our approach for the last 15 years has been to work these problems in the international forum of the Consultative Committee for Space Data Systems (CCSDS). The CCSDS is composed of some 30 space agencies of the world, all with similar problems to ours, and has collaboratively produced over 20 different Recommendations (Blue Books). Having engineers from several different agencies working on a solution leverages our contributions to get a superior engineered result. While this international approach helps industry by enlarging the market for standard products and solutions, it also enhances the ability of (the Telecommunications and Mission Operations Directorate (TMOD) to service its many foreign customers (~50%). CCSDS has also been found beneficial to NASA by providing a neutral, third-party umbrella under which NASA centers find it easier to cooperate. (It neutralizes the inter-center "not invented here" syndrome.) Furthermore, in the last two years, a cooperative effort among NASA, the National Oceanic and Atmospheric Administration (NOAA), and the Department of Defense (DOD) has been formed to respond to the White House thrust to establish commonality among all government space operations. This has the potential to enlarge the vendor market for standardized products and make more of them available cheaply and quickly ("off the shelf"), particularly if (as is already happening) this thrust is carried into CCSDS.

Technical Areas Standardized

There are three major technical areas in which the Information Systems Standards are concerned: *Space Communications* (which moves the data without its interpretation); *Information Interchange* (which deals with the interpretation of the data content but not its transport); and provisioning of *Mission Services* for routine operations such as data delivery, scheduling, and tracking operations.

Space Communications Standards

These standards use a layered approach to communication protocols that have been adapted

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DS-T DEVELOPMENT

NASSER GOLSHAN

Introduction

A fast-track prototype effort has begun to validate the concept of a fully automated, autonomous, ground station that simplifies implementation, operation, and reduction of the life-cycle cost of tracking deep space missions at the Deep Space Network (DSN). The origin of the Deep-Space Terminal (DS-T) is the successful development of the Low Earth Orbit Terminal (LEO-T), the prototype for a new class of low-cost ground station to reduce life-cycle costs of tracking the National Aeronautics and Space Administration's (NASA's) missions in low-earth orbit.

Development of the predecessor, LEO-T, was carried out in two phases by a small team of engineers at the Jet Propulsion Laboratory (JPL) and at SeaSpace Inc., a satellite ground terminal manufacturer in San Diego, California. Autonomous, unattended telemetry operation was successfully demonstrated by tracking two NASA science satellites—the Solar Anomalous and Magnetospheric Particle Explorer (SAMPEX), and the Extreme UltraViolet Explorer (EUVE), both operated by NASA's Goddard Space Flight Center, in Greenbelt, Maryland. In the second phase, command uplink capabilities were added to the prototype terminal by JPL. A successful, week-long demonstration of the automated unattended uplink and telemetry operation of the LEO-Terminal with the COBE (COsmic Background Explorer) spacecraft was completed at JPL on December 28, 1995. The LEO-T concept is now generally accepted by the NASA community as the ground station of choice for low-cost support of near-earth missions.

The DS-T effort will carry the LEO-T paradigm to NASA's Deep Space Network, enabling significantly lower costs for ground support of missions, as well as improved reliability and data flow. Lower costs are expected in ground systems development, implementation, maintenance, and operations.

DS-T Design

The prototype DS-T is being implemented at the DSS-26 34-m beam waveguide antenna. In addition to the antenna system, DS-T includes an X-Band microwave system, a 4 kW transmitter, and a DS-T electronics rack. The latter combines all baseband telemetry and uplink functions, as well as all high-level monitor and control operations of the station for unattended, autonomous operations. Figure 1 shows a strawman block diagram for DS-T.

The DS-T electronic rack is being built entirely from commercially available subsystems. Use of Commercial-off-the-Shelf (COTS) equipment has enabled a rapid, low-cost, development cycle, and will ensure low recurring costs for future users. The electronics rack includes the telemetry receiver, command exciter, and an Ultra 2 Sun workstation, all COTS equipment.

The workstation provides for automated, unattended operations of the terminal, including scheduling, calculation of spacecraft trajectory and frequency predicts, automated uplink and telemetry operations, communication interfaces for remote command operations, as well as processing and distribution of spacecraft engineering and science telemetry data to the mission operations and science users of the data. In its current configuration, the terminal will receive telemetry at rates up to 1.2 Mbps, and uplink commands at rates up to 2 kbps. However, the operating frequency and the ceilings on telemetry and uplink rates of the terminal can be modified easily by replacing the appropriate modules of the terminal with other commercially available equipment consistent with the desired data rates and operating frequencies.

The X-band microwave system includes a corrugated horn, a horn diplexer, a commercial cryogenic low noise amplifier (LNA) package (including a high-electron mobility transistor (HEMT) amplifier and a cooled filter to reject the uplink RF leakage into the LNA), as well as microwave waveguides for uplink and downlink.

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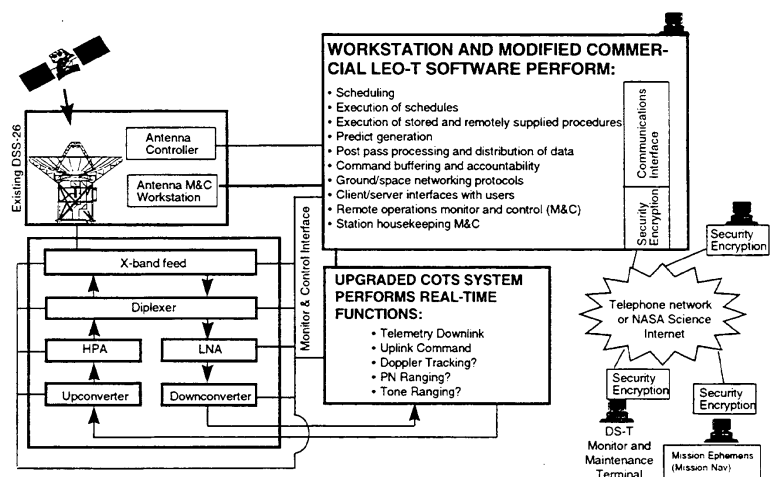


FIGURE 1. STRAWMAN BLOCK DIAGRAM FOR DEVELOPMENT OF DS-T.

